INFLUENCE OF GENETIC ENVIRONMENT ON THE REDUCTION OF BRISTLES BY THE DICHAETE GENE IN DROSOPHILA MELANOGASTER

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Introduction

The interaction and influence of one gene upon another is one of the methods employed in the study of gene action. The influence on the Dichaete gene can be readily measured, for this gene removes the bristles in the region of the presutural bristles. Thus, a bristle is either present or absent, and the quantitative effect can be accurately determined. Various mutations were brought into combination with the Dichaete gene, and the effect on the number of bristles was recorded.

Gene action has been analyzed by studying the effects of different dosages of mutant genes upon the phenotype (Stern, 1929, 1943; Schultz, 1935). Another method is to prolong larval life by means of low temperatures, genes or starvation (Green and Oliver, 1940; Green, 1946; Dunn and Coyne, 1935). High temperatures, which shorten larval life, cause a decrease in the number of bristles in the mutant Dichaete (Plunkett, 1926), and alter the phenotype in other Drosophila mutants (Stanley, 1931; Child, 1935; Harnly, 1936). Neel (1941) and Sparrow and Reed (1940) reported on the interaction of mutants that affect the chaetae of *D. melanogaster*. Stone (1947) used the effect of several mutants on Dichaete in an attempt to discover whether differences existed in reciprocal crosses.

An attempt was made to find a relationship, if one existed, between the number of bristles of the Dichaete mutant and the following mutations: Bar (B), black (b), Curly (Cy), eosin (w^e), eyeless (cy), heldout (ho), Lobe^2 (L^2), vestigial (vg), white (w), and yellow (y). The above mutants were picked for two reasons: one is that they were not in the third chromosomes, and that the mutations by themselves had no apparent effect on the thoracic bristles.

Methods

The Dichaete gene and the above mutant genes were placed in a common genetic background by the following method. The highly inbred Dichaete stock (inbred brother and sister for nine generations) was crossed to the mutants and then the mutants were extracted. This procedure was repeated eleven times for each mutant, and according to the formula developed by Bartlett and Haldane (1935) about 14 to 18 units on either side of the mutant gene remained heterozygous.

Plunkett (1926) reported that the bristle number of Dichaete flies was influenced by poor food conditions, high temperatures and crowding. Since the environment has a definite effect on bristle number, all matings were made under uniform conditions. The flies were raised at 24° C., and the same amount of

cornmeal-agar formula was used in each one-half pint bottle. Pair matings were used, and the parents were removed at the end of four days.

Bristles were counted on the right side of the scutellum, mesonotum, and on the right humerus. There are a total of twenty-six thoracic bristles, and the bristle count of the right half of the wild fly was then thirteen. The mean bristle count for the Dichaete stock was 10.634 ± 0.306 (♀♀) and 10.789 ± 0.147 (♂♂). The presutural, anterior supra-alars, and anterior dorsocentrals were the bristles that were usually missing in the Dichaete stock.

TABLE I

Genotype	Mean number of thoracic dorsal bristles of one-half of the fly (right side)			
	♀♀	No.	♂♂	No.
D/+	10.634 ± 0.306	592	10.789 ± 0.147	493
D/+ *B*/+	10.325 ± 0.896	623	10.394 ± 0.642	601
D/+ *b*/*b*	10.723 ± 0.711	246	10.641 ± 0.541	315
D/+ *Cy*/+	8.724 ± 0.742	419	8.970 ± 0.866	486
D/+ *ey*/*ey*	10.774 ± 0.419	283	10.861 ± 0.302	206
D/+ *ho*/*ho*	12.818 ± 0.149	336	12.444 ± 1.148	376
D/+ L^2/+	10.191 ± 1.391	484	10.889 ± 0.168	479
D/+ *vg*/*vg*	11.250 ± 0.521	229	12.253 ± 0.636	288
D/+ *w*/*w*	10.841 ± 0.413	396	10.718 ± 0.662	384
D/+ w^e/w^e	10.639 ± 0.523	344	10.392 ± 0.493	369
D/+ *y*/*y*	10.614 ± 0.614	248	10.743 ± 0.714	293

The Dichaete stock was crossed to each of the above mutants. Both ♀ and ♂ Dichaete flies were employed. The thoracic bristles were counted in the F_1 in the case of *B*, *Cy*, L^2 and in the Dichaete males containing *w*, w^e, and *y* genes. The other combinations were counted in the F_2.

RESULTS

In Table I the mean (or average) and the standard deviation of the mean of the thoracic dorsal bristles (right side) of *D*/+ and other genotypes are presented. In the Dichaete Curly cross, the *D*/+ *Cy*/+ flies had a lower mean (8.724 ± 0.742♀♀). This is a highly significant difference compared to mean of 10.634 ± 0.306♀♀ of *D*/+, for the difference is more than three times the probable error. The genes *vg* and *ho* significantly increased the mean of the bristle number to 11.250 ± 0.521 and 12.818 ± 0.149 respectively for females. The *B*, *b*, *ey*, L^2, *w*, w^e, and *y* genes had no influence upon the thoracic bristles when in combination with the *D* gene. The males had a slightly higher mean number of bristles than the females.

DISCUSSION

The action of the Dichaete gene had been postulated by Plunkett (1926) to remove bristles in a direction radiating outward from the presutural bristle. A catalyst which decomposes another bristle-forming catalyst was the manner in which bristles were supposed to be removed. Neel (1941) questioned the ex-

istence of the above diffusion hypothesis in scute, but in counting the bristles of Dichaete flies and Dichaete-mutant combinations it was evident that a gradient existed. In flies with 12 bristles on the right side, it was always the presutural bristle that was missing. In the *D*/+ *Cy*/+ combination, the bristles anterior notopleural, anterior supra-alars, anterior dorsocentral, and upper humerals were the bristles that were usually missing. There was a gradient present in the direction of the anterior supra-alar bristle. It is possible that the bristle-removing substance produced by the Dichaete gene is different from that found in scute, although they both remove bristles.

The Dichaete gene evidently produces substances directly or indirectly that destroy or inhibit the bristles. Now this system is disrupted by high temperatures which evidently speed up a reaction or reactions which produce more bristle-destroying or inhibiting substance, and thus a fly with fewer bristles is the result. The above system of removing or limiting the number of bristles is thrown out of balance by poor food conditions and low temperatures which evidently slow down the reactions and permit the bristle-destroying catalyst or bristle-inhibiting substance to act for a longer time, again producing flies with fewer bristles.

One encounters some difficulty in using the above scheme in explaining the effect of genes upon the Dichaete bristle system that neither increases nor decreases the life cycle of the flies. The *Cy* gene reduces the number of bristles in a Dichaete fly, and yet it neither speeds up nor slows down the length of time the individual insect spends in egg, larval, or pupal stages. Evidently the *Cy* gene produces in some way a larger amount of the bristle-destroying or inhibiting substances or may cause these substances to begin reacting earlier and to last longer.

The Curly gene turns the tips of the wings upward, and is a small inversion in the second chromosome. *D* is also a result of an inversion, and besides removing bristles also spreads the wings apart at a 45° angle. This may be a coincidence, or there may be a relationship between wing mechanism and bristle formation. The presence of genetic modifiers in the *Cy* inversion has to be considered. However, the method of inbreeding and selection would result in the *Cy* flies all having the same chromosome rearrangement. If the *Cy* flies used contained different genetic modifiers, the *D*/+ *Cy*/+ flies would have a greater standard deviation of the mean (would be more variable) than the *D*/+ flies. This difference is not significant (Table I).

The *vg* and *ho* genes are wing mutants, and they increase the length of time spent in the larval stage. One would expect a low bristle number according to Plunkett's hypothesis (1926), but that is not the case (Table I). It may be the interruption of the wing forming mechanism that influences the removal of bristles by the Dichaete bristle destroying substance. There appear to be several unrelated factors which can cause a variation in the number of bristles reduced by the Dichaete gene. Thus, the bristle destroying substance does not act simply upon a bristle forming substance. One cannot say that a substance *A* produces *B* which is a precursor of a bristle destroying substance *C* which acts upon a substance *D* which in turn produces bristles. There are probably more than three substances in the chain, and there is evidence, because of diverse environmental and genetic modifiers, that numerous side chain reactions exist that influence the step by step production of the bristle destroying or inhibiting substance. It is

a complex process in that these variable factors may work at different times or several together at various times. Temperature, food conditions, other seemingly unrelated genes, and chromosome arrangements play an important role in the action of the Dichaete gene.

Summary

A highly inbred Dichaete (*D*) stock of *D. melanogaster* was crossed to isogenic stocks carrying various mutations, which by themselves had no apparent effect upon thoracic bristles. The Curly gene (*Cy*) in combination with *D* decreased the average number of one half the thoracic bristles from 10.634 ± 0.306(♀♀) to 8.724 ± 0.742. The *Cy* gene is an inversion on the second chromosome, and it aids the *D* gene, which is on the third, in the removal of a larger number of bristles. Vestigial (*vg*) and heldout (*ho*) increase the bristle number to 11.520 ± 0.521 and 12.818 ± 0.149 respectively. *Vg* and *ho* increase the larval life, and disrupt the production of a wild type wing.

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